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Bioactive Compounds in *Trichosanthes cucumerina*, Their Bioactivities, and Associated Health Benefits: A Review

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Abstract

Trichosanthes cucumerina Linn., commonly known as snake gourd, is a climbing plant belonging to the Cucurbitaceae family, widely grown in tropical and subtropical regions. Traditionally, it has been valued for its nutritional and medicinal properties, with various parts such as the leaves, fruits, seeds, and roots used in folk medicine to address ailments like fever, inflammation, digestive disorders, diabetes, and respiratory problems. The plant is rich in bioactive compounds including flavonoids, alkaloids, saponins, and triterpenoids, which are responsible for its broad spectrum of pharmacological activities such as antioxidants, antimicrobial, antidiabetic, and hepatoprotective effects. In addition, its low caloric value and high nutrient density make it suitable as a functional food. This review discusses the plant's botanical characteristics, phytochemical profile, and pharmacological actions, along with its therapeutic potential and industrial relevance in both pharmaceutical and nutraceutical domains. The study is based on a detailed analysis of information gathered from scientific literature, ethnopharmacological records, and published research data. The significance of this work lies in recognizing the untapped medicinal potential of *T. cucumerina,* which, despite its widespread availability and traditional use, remains underexploited. Integrating ethnomedicinal knowledge with modern pharmacological validation can lead to the development of affordable, plant-based therapeutic alternatives. The rationale compiling this review is to consolidate and interpret available data, serving as a resource base for future experimental research, clinical testing, and the formulation of effective herbal products or health-promoting dietary supplements using this versatile plant. The main objective of this review is to provide a comprehensive understanding of *T. cucumerina* by evaluating its botanical description, phytoconstituents, pharmacological activities, and therapeutic relevance, thereby supporting its potential utilization in modern herbal medicine and functional food development.

Keywords

Trichosanthes cucumerina, Snake gourd, Pharmacology, Nutrition, Phytochemicals, Medicinal plants

Introduction

T. cucumerina Linn commonly known as snake gourd, is an herbaceous, annual climber belonging to the family Cucurbitaceae. Native to tropical Asia, it is widely distributed across countries such as India, Sri Lanka, the Philippines, and regions of the Malay Peninsula. In recent decades, there has been a resurgence of interest in traditional medicinal systems, driven by factors like rapid population growth, limited accessibility to modern healthcare, rising costs of treatment, undesirable side effects of synthetic drugs, and escalating resistance to conventional therapeutics particularly antibiotics and antiparasitic. This growing global health

challenge has reinforced the need to explore alternative and complementary plant-based remedies [1, 2].

T. cucumerina holds a prominent place in ethnomedicine due to its diverse pharmacological attributes. Every part of the plant including the roots, leaves, fruits, seeds, and aerial structures has demonstrated therapeutic potential. The roots are traditionally used to treat bronchitis, headaches, and inflammatory skin conditions like boils. Leaf extracts are externally applied to the liver area for alleviating hepatic congestion. The root and fruit are recognized for their cathartic properties, while the fruit also serves as an anthelmintic in regions like French Guiana. Along the Malabar Coast, seeds are utilized for their reputed antifebrile and anthelmintic actions in managing gastrointestinal disorders [3, 4].

When used synergistically with other medicinal plants, the aerial parts of *T. cucumerina* have shown promise in treating chronic skin disorders such as urticaria, eczema, psoriasis, and dermatitis, as well as metabolic and inflammatory conditions including diabetes, ulcers, and bilious fevers. Notably, the plant is a rich reservoir of bioactive phytochemicals such as flavonoids, carotenoids, and phenolic acids which contribute to its significant antioxidant potential by neutralizing reactive oxygen species [5-7]. This review aims to provide a thorough analysis of the existing knowledge regarding nutritional value, bioactive components, health benefits, and value addition of *T. cucumerina* (Table 1 and table 2).

Botanical description

The annual herb *T. cucumerina* is monoecious and grows to a height of 5 - 6 meters by tendrils with two to three branches. The thin, green, slightly hairy stems have a little scent [8]. Its growth is supported by its whitish, tuberous roots. The simple alternating leaves have a heart-shaped base, are 7 - 14 cm long, broad, and have three to five lobes [9]. Both of their surfaces are covered in scabrid hairs. Male flowers are white, regular, unisexual, and grow long peduncles with six to fifteen flowers in axillary racemes. Female flowers are sessile and solitary, with an inferior, single-celled ovary. The fruit is a spherical, slender berry that is dark crimson when ripe and greenish-white when young (Figure 1). It is about one-centimeter-long, greyish-brown, rugose seeds are covered with a silky, odorous scarlet pulp [10].

Origin and distribution

The genus *Trichosanthes* is native to Australia, the western Pacific Islands, and Southern and Eastern Asia. The wild *T. cucumerina*, which was most likely domesticated in ancient India, can be found in these regions. In tropical Asia, it is used as a minor vegetable and is widely grown in household gardens across Africa. Commercial farmers in large East African cities may grow snake gourd cultivars imported from India to cater to communities of Indian descent. The plant, which thrives in climates that are suitable for it, has also been found in tropical regions of Australia, India, and Malaya. *T. cucumerina*, one of the approximately 100 species in its genus, is a crop that has gained importance recently in Africa (including Ghana and Nigeria). There are two varieties, found in northern Australia and Asia: wild var. cucumerina west and Central Africa employ traditional landraces, whilst East Africa produces superior cultivars [11].

Table 1: Common name of *T. cucumerina*.

Language	Common name
English	Snake gourd, Serpent gourd, and Snake cucumber
Hindi	Chichinda
Bengali	Chichinga
Tamil	Pudalankai
Malayalam	Padavalanga
Kannada	Padavalakayi
Telugu	Potlakaya
Marathi	Padwal
Gujarati	Pandoḷ
Assamese	Dhunduli
Odia	Chhachinda
Punjabi	Gala tori

Table 2: Taxonomic classification of *T. cucumerina*.

Taxonomic rank	Classification
Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Cucurbitales
Family	Cucurbitaceae
Genus	*Trichosanthes*
Species	*T. cucumerina*

Figure 1: Different parts of *T. cucumerina*: **(A)** Leaves, **(B)** fruit, **(C)** flower, and **(D)** seed.

Methodology

From 2010 to 2020, the Breeding and Biodiversity Laboratory at Vegetable Research and Development Station in Buzau, Romania, studied seven genotypes of *T. cucumerina* using International Plant Genetic Resources Institute guidelines.

Selection criteria

The selected genotype exhibited a fruit length of at least 100 cm, uniform fruit shape and color, an average yield of 3.5 kg or more per plant, healthy growth without major pest or disease damage, a favorable male-to-female flower ratio, and stable trait expression over a minimum of three consecutive seasons.

Validation Steps

Measurement methods for traits were adapted from published Cucurbitaceae studies and tested over multiple seasons

to ensure reliability. Qualitative traits (e.g., leaf margin and flower color) were assessed visually, while quantitative traits (e.g., plant height, leaf size, fruit length, and fruit weight) were measured using rulers, calipers, and weighing scales. Data analysis included Pearson correlation and Duncan's test ($p < 0.05$).

Phytochemistry and bioactive compounds

T. cucumerina is a highly nutritious plant, rich in proteins, fats, fiber, and carbohydrates. Vitamins A, C, and E are present at considerable levels [12-16]. The total phenolic and flavonoid contents are 46.8% and 78.0%, respectively [17]. The crude protein content is 30.18%. Among its predominant mineral elements, potassium (121.60 mg/100 g) and phosphorus (135.0 mg/100 g) are present in high concentrations. Additionally, it contains notable amounts of sodium, magnesium, and zinc [18]. Proteins, fiber, vitamins A, C, and E, as well as vital minerals like potassium, phosphorus, magnesium, and zinc, are all abundant in *T. cucumerina*. It contains a significant amount of crude protein (30.18%), as well as substantial levels of flavonoids (78.0%) and phenolics (46.8%). Cucurbitacins, sterols (β-sitosterol, stigmasterol), and triterpenes are among their bioactive constituents, which make it advantageous for industrial and nutritional uses. The seed oil is useful for a variety of purposes due to its stability and high production (42.5%) [19]. Cucurbitacin B, cucurbitacin E, is cucurbitacin B, 23,24-dihydroisocucurbitacin B, and 23,24-dihydrocucurbitacin are the main chemical components of *T. cucumerina*. Antinutritional components such as tannins, phytates, and oxalates are also found in trace amounts [20, 21].

A ribosome-inactivating protein called trichoanguin and a galactose-specific lectin are found in the plant's aerial portions [22]. Lutein, the most abundant carotenoid, is found in concentrations ranging from 15.6 to 18.4 mg/100 g fresh weight. According to circular dichroism spectroscopy, *T. cucumerina* seed lectin is composed of roughly 28.4% beta-sheet, 10.6% beta-turns, and 7% polyproline type 2 structures, with the remainder being unordered; there is very little alpha-helix. While β-carotene is present in amounts of 2.4 - 2.8 mg/100 g, α-carotene ranges from 10.3 to 10.7 mg/100 g fresh weight [23-27]. Furthermore, the concentration of lycopene ranges from 16.0 to 18.1 mg/100 g, while the ascorbic acid content ranges from 24.8 to 25.7 mg/100 g fresh weight. *T. cucumerina* fruit pulp had higher levels of carotenoid (2053.33 mg/100 g), flavonoid (861.67 mg/100 g), cardiac glycoside (11.67 mg/100 g), alkaloids (93.33 mg/100 g), lycopene (118.5 µg/100 g), tannin (555.00 mg/100 g), oxalate (2.55 mg/100 g), and quercetin (5.25 mg/100 g) (Table 3).

Bioactivities of *T. cucumerina*

Hepatoprotective activity

A poisonous substance called carbon tetrachloride (CCl_4) destroys the liver by rupturing cell membranes, which causes liver enzymes like aspartate transaminase and alanine transaminase to seep into the blood [30, 31]. Liver injury is indicated by this rise in enzymes. Bile flow is also impacted by CCl_4, which raises bilirubin levels. However, bilirubin levels can be lowered and liver function preserved by administering 250 and 500 mg/kg of *T. cucumerina* methanol extract. By harming the endoplasmic reticulum, CCl_4 also reduces the creation of proteins, whereas *T. cucumerina* methanol extract maintains protein synthesis. Furthermore, oxidative stress brought on by CCl_4 results in lipid peroxidation, which raises malondialdehyde (MDA) levels and decreases glutathione. This oxidative damage is lessened by *T. cucumerina* methanol extract antioxidant qualities. According to histopathological research, CCl_4 severely damages the liver cells surrounding the central vein, although *T. cucumerina* methanol extract pretreatment considerably lessens damage. These results imply that *T. cucumerina* methanol extract protects against liver toxicity by lowering oxidative stress, cellular damage, and enzyme leakage [32].

Cardioprotective activity

Particularly at larger dosages, the chemotherapy medication doxorubicin (DOX) can result in heart issues such as irregular heartbeats and chronic heart muscle deterioration. This damage is often linked to elevated blood levels of certain enzymes that are indicative of heart disease, such as lactate dehydrogenase and creatine kinase-myocardial band (MB) [33]. According to research, extracts from the fruit of *T. cucumerina*, a plant high in carotenoids, vitamin C, and antioxidants like cucurbitacin B and E, can lower these enzyme levels, which may indicate reduced heart damage. Longer ST, QT, and QRS intervals on electrocardiography measurements following DOX administration in animals suggested problems with cardiac rhythm. Nevertheless, in groups administered 500 mg/kg and 1000 mg/kg of *T. cucumerina* extract, these intervals stayed normal. Additionally, *T. cucumerina* therapy reversed the effects

Table 3: Active constituent's different parts of *T. cucumerina*.

Classification	Chemical compounds	Plant parts	Ref.
Flavonoids	Kaempferol and quercetin	Leaves and fruits	[28]
Triterpenoids	Cucurbitacin and lupeol	Leaves, fruits, and roots	[28]
Alkaloids	Trichosanthin and other alkaloids	Leaves and roots	[28]
Saponins	Various saponins	Leaves, seeds, and roots	[29]
Phenolics	Gallic acid and ferulic acid	Leaves and fruits	[29]
Carotenoids	Lycopene and β-carotene	Fruits	[29]
Steroids	β-sitosterol	Fruits, seeds, and stem	[28]
Fixed oils	Oleic acid, linoleic acid, and palmitic acid	Seeds	[28]
Polysaccharides	Trichosan A and other polysaccharides	Roots	[29]
Lignans	Various lignans	Stem and inner bark	[29]
Tannins	Condensed tannins	Stem and leaves	[29]
Ascorbic acid	Vitamin C	Fruits	[28]

of DOX, which decreased both systolic and diastolic blood pressure. According to these results, *T. cucumerina* might provide protection against cardiac toxicity brought on by DOX.

Gastroprotective activity

Due to diminished mucus formation, mast cell degranulation, endothelin release, microcirculatory abnormalities, and prostaglandin suppression, ethanol is a highly ulcerogenic drug that harms the stomach mucosa. A non-steroidal anti-inflammatory drugs called indomethacin inhibits prostaglandins, which causes ulcers by lowering mucus and boosting acid output. Strong gastroprotective benefits are demonstrated by *T. cucumerina*, which considerably lessens stomach lesions brought on by ethanol and indomethacin [34]. Its extract of boiling water, at 750 mg/kg, demonstrated protection on par with that of sucralfate and cimetidine. In order to support mucosal defense, hot water extract increases the release of stomach mucus, decreases acidity, and may increase the production of prostaglandins. Its antihistamine-like properties also help lower stomach acidity, which further prevents ulcers.

Antidiabetic activity

In diabetic rats, an aqueous extract of *T. cucumerina* (AET) dramatically reduced blood glucose levels ($p < 0.01$). Glucose levels in rats with untreated diabetes peaked at 45 min and remained elevated for 2 h, but in rats treated with AET, glucose peaked at 30 min and then started to decline. Additionally, AET increased skeletal muscle (58.8%) and liver (62%) glycogen levels, indicating greater glucose absorption and decreased insulin resistance. In both normal and diabetic rats, a hot water extract of *T. cucumerina* also reduced blood glucose and enhanced glucose tolerance. It increased liver glycogen without altering intestinal glucose absorption, much like sulfonylureas do. *T. cucumerina* extract enhanced fat metabolism and decreased blood sugar in streptozotocin-induced diabetes. It is a promising natural antidiabetic medication since it may improve insulin sensitivity and the activity of pancreatic β-cells [35].

Antifertility activity

Growth factors, gonadal steroids, and pituitary hormones all control follicle formation. Follicle dynamics and follicle-stimulating hormone (FSH) secretion are influenced by ovarian androgens and inhibin's. One important component of the hypothalamopituitary unit's vital role in ovarian function is glycoprotein hormones. *T. cucumerina* L. high-dose ethanol extract decreased ovarian weight in intact rats, most likely via blocking pituitary gonadotropin release through estrogenic negative feedback. As a result, there was less FSH and Replace with luteinizing hormone (LH) in the blood. Elevated estrogen levels and decreased FSH support for follicular expansion were associated with alterations in vaginal cornification and the length of the oestrous cycle. Rats given extract had reduced levels of ovarian glycogen, which suggested compromised function. Elevated ovarian cholesterol indicated gonadotropin suppression-induced disruption of steroidogenesis. Ovulation and the oestrous cycle were hampered by the extract's inhibition of LH and FSH release. Overall, gonadotropin secretion and steroid hormone synthesis were disrupted by ethanol extract administration, which had a deleterious impact on ovarian function [36, 37].

Anti-cancer activity

T. cucumerina cucurbitacin B has shown potent anti-cancer properties against breast cancer cells. It showed no effect on SKBR-3 cells; however, it increased the radiation sensitivity of MDA-MB-231 and MCF7:5C cells. By raising p21 levels and upsetting microtubules, it resulted in G2/M cell cycle arrest. This suppressed Wnt signaling and promoted apoptosis by lowering c-Myc, nucleophosmin/B23, cyclin D1, β-catenin, and galectin-3 [38, 39]. Cucurbitacin B had IC_{50} values of 4.60 and 88.75 µg/mL in SKBR-3 and MCF-7 cells, respectively. Additionally, it decreased invasion, migration, and proliferation, particularly in breast cancer cells lacking breast cancer gene 1 (BRCA1). Cucurbitacin B efficiently repressed survivin while increasing p21 and p27, whereas loss of BRCA1 raised survivin levels and reduced paclitaxel sensitivity. It was less effective in cells with wild-type BRCA1 and more effective in cells with BRCA1 mutations [40, 41]. According to these results, cucurbitacin B may be helpful in the treatment of breast cancer that lacks BRCA1 (Table 4 to table 6).

Regional medicinal value of *T. cucumerina*

Many civilizations have used the tropical vine known as snake gourd (*T. cucumerina*) in traditional medicine because of its many therapeutic uses. Its possible health advantages have been investigated in recent studies, supporting its medical significance (Table 7) [47].

Table 4: Nutritional composition of snake gourd.

Food class	Amount	Daily intake
Calorie	86.2 kcal	-
Total fat	3.9 g	-
Solid fats	0.5 g	-
Polyunsaturated fat	1.6 g	-
Monounsaturated fat	1.6 g	-
Total carbohydrate	12.5 g	-
Dietary fiber	0.6 g	-
Sucrose	0.6 g	-
Sodium	33.0 mg	-
Pantothenic acid	-	3.0%
Pyridoxine	-	11.3%
Cobalamin	-	0.0%
Ascorbic acid	-	30.5%
Calciferol	-	0.0%
Tocopherol	-	1.1%
Calcium	-	5.1%
Copper	-	4.4%
Folate	-	5.6%
Riboflavin (B2)	-	2.7%
Selenium	-	3.1%
Thiamin (B1)	-	5.2%

Table 5: Nutritional composition of the seed.

Nutrient	Composition (per 100 g)
Crude protein	26.2 - 26.6 g
Fat	44.6 - 57.2 g
Phosphorus	78.0 - 81.5 mg
Calcium	41.0 - 46.7 g

Table 6: Nutritional composition of the leaves.

Nutrient	Composition (per 100 g)
Calcium	2500 mg
Potassium	1500 mg
Magnesium	200 mg
Iron	15 mg
Zinc	3 mg

Ethnomedicinal value

T. cucumerina is used to treat headaches, hair loss (alopecia), fever, abdominal tumors, bile-related issues, boils, stomach pain (colic), diarrhea, blood in urine (hematuria), and skin allergies. It also serves as an abortifacient, helps expel worms (vermifuge), improves digestion (stomachic), cools the body (refrigerant), acts as a laxative and purgative, treats malaria and bronchitis, and works as an emetic, cathartic, and anthelmintic (for worm infections) [48-53].

The roots have long been used in China to treat diabetes and skin conditions including boils and furuncles. The bulbous portion of the root functions as a hydragogue and cathartic, while the fresh root has anticonvulsant qualities. The root also has aborticide, emetic, parasiticidal, diuretic, astringent, antiseptic, and alexiteric properties [54, 55].

The body is treated with leaf extract to lower fevers. Spasm is lessened by dried leaves. While the juice from the leaves can cause vomiting, an infusion made from young shoots and dried capsules acts as a moderate laxative. The stems and leaves are used to encourage menstruation flow and treat bile-related problems. Additionally, leaves are reported to have emetic, styptic, and detoxifying qualities [56-59].

To help with digestion, the dried capsules are combined with sugar to make an infusion or decoction. Additionally, fruit has potent emetic and purgative properties [60-62].

The dried seeds are used as an anthelmintic to treat diarrhea and to get rid of worms. They are also used to prevent recurrent fevers (antiperiodic) and have antimicrobial, antispasmodic, and insecticidal qualities (Figure 2). The acrid, aphrodisiac, astringent, bitter, purgative, poisonous, fever-reducing (febrifuge), and hair-growth-promoting (trichogenous) qualities of seeds are also employed as an abortifacient [63].

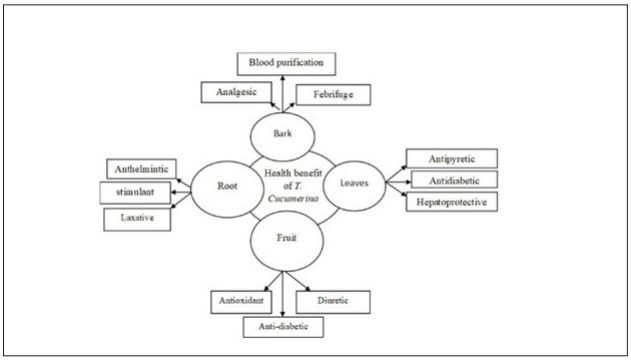

Figure 2: Health benefits of *T. cucumerina*.

Results and Discussion

A number of studies have reported that *T. cucumerina* is a rich source of phytochemicals with diverse pharmacological activities, including antioxidant, anti-inflammatory, hepatoprotective, antidiabetic, and antimicrobial effects. Phytochemical screening of different plant parts fruits, leaves, seeds, and roots has consistently revealed the presence of bioactive constituents such as cucurbitacins, triterpenoids, flavonoids, phenolic acids, saponins, alkaloids, and glycosides. These findings align with the present results, which also confirm a broad phytochemical profile, supporting previous research on the plant's medicinal properties.

The cumulative evidence highlights *T. cucumerina* as a multifunctional medicinal plant, with its pharmacological effects likely arising from the synergistic action of its diverse phytochemicals. However, similar to earlier reports, our study acknowledges that most available data stems from *in vitro* and animal models, with limited clinical validation in humans. Furthermore, consistent with previous observations, factors such as genotype, geographical origin, and extraction methodology can significantly influence the phytochemical yield and composition.

By comparing our findings with previous literature, it becomes evident that while the plant shows promising therapeutic potential, there is an urgent need for bioassay-guided isolation of active constituents, elucidation of mechanisms of action, and rigorously designed clinical trials to substantiate its efficacy and safety in humans.

The plant's widespread traditional use and growing pharmacological evidence, a comprehensive and integrative synthesis of its phytochemical composition, bioactivities, and associated health benefits remains limited in the existing literature. Previous studies and reviews on *T. cucumerina* have often focused on either its ethnomedicinal relevance, specific pharmacological properties, or limited phytochemical analyses, without providing a consolidated account that links bioactive constituents to experimentally validated biological activities and potential therapeutic applications.

Table 7: Medicinal value of *T. cucumerina*.

Region	Medicinal uses	Ref.
India (Ayurveda and Siddha) - 35%	Treats fever, jaundice, diabetes, and skin diseases. Used as a laxative and for respiratory issues	[42]
China (traditional Chinese medicine) - 25%	Help with detoxification, cooling effects, and reducing inflammation. Used for blood purification and treating ulcers	[43]
Africa - 15%	Used for gastrointestinal disorders, including dysentery. Treats wounds and infections	[44]
Southeast Asia - 15%	Used for curing intestinal worms and fever. Leaves and roots are helpful for hair care and skin ailments	[45]
Other regions - 10%	General use for diabetes, cardiovascular health, and as a diuretic	[46]

Conclusion

The preclinical evaluation of *T. cucumerina* has provided compelling evidence of its hepatoprotective, anti-diabetic, antioxidant, and immunomodulatory properties, thereby scientifically validating its traditional therapeutic use. These findings bridge the gap between ethnomedicinal knowledge and modern pharmacological research, establishing the plant as a valuable candidate for managing metabolic and hepatic disorders. The identification of bioactive constituents in *T. cucumerina* not only enhances our understanding of its pharmacological potential but also positions it as a promising source for natural product drug discovery. Importantly, the study highlights critical avenues for future research, including in-depth mechanistic investigations, comprehensive toxicity profiling, and clinical evaluation to ensure its safety and therapeutic efficacy in humans. By addressing these research gaps, the current work lays a strong foundation for the development of standardized, evidence-based herbal formulations and emphasizes the importance of scientifically exploring underutilized medicinal plants in the pursuit of novel therapeutic agents.

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None.

Conflict of Interest

None.

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